REMARKS

Status of the Application and Claims

This paper (Response D) is submitted in response to the non-final office action (the Office Action) mailed on October 25, 2004. Applicants have, on three previous occasions, amended and/or responded to the Examiner's rejections. In summary, prosecution of the present application has proceeded as follows:

- The Examiner issued a March 25, 2003 restriction requirement. Applicants responded on April 24, 2003 (Response to Restriction Requirement) by electing claims 1-23 and 48 as well as the species disclosed in Figures 2 and 3; amendments were made to, *inter alia*, independent claim 15.

- The Examiner issued an October 22, 2003 non-final office action rejecting claim 1 under 35 U.S.C. § 102(e) and claims 2-9, 15-17 and 48 under 35 U.S.C. § 103(a). Applicants responded on January 16, 2004 (Amendment A). In addition to contesting the Examiner's rejections, Applicants amended independent claims 1, 2, 15 and 48.

- The Examiner issued an April 13, 2004 final office action now rejecting claim 1 under 35 U.S.C. § 102(b) but continuing to reject claims 2-9, 15-17 and 48 under 35 U.S.C. § 103(a). Applicants responded on July 13, 2004 (Amendment B). In addition to contesting the Examiner's rejections, Applicants further amended independent claims 1, 2, 15 and 48. Applicants also argued for the reintroduction of claims 10-14 and 18-23 contending generic claim 1 to be in condition for allowance.

- The Examiner issued the present Office Action on October 25, 2004. The Examiner, in the present action, rejects *all* claims under 35 U.S.C. § 103(a) as follows:

Claim 1: Unpatentable over (a) *Smith et al.* (5,744,898) in further view of *Miller et al.* (5,267,221) or *Kunkel, III* (5,648,942) or (b) *Chiang et al.* (5,690,114) in further view of *Miller et al.* or *Kunkel* or *Gilmore* (6,043,590).

Claims 2-4: Unpatentable over *Smith et al.* and *Chiang et al.* in further view of *Miller* (6,551,248) in further view of *Miller et al.* or *Gilmore.*

Claim 5: Unpatentable over *Smith et al.* and *Chiang et al.* in further view of *Miller et al.* or *Gilmore* in further view of *Daigle et al.* (5,795,297).

Claims 6-9, 15-17 and 48: Unpatentable over *Chiang et al.* and *Smith et al.* in further view of *Miller et al.* or *Gilmore* and further in view of *Kunkel.*

Applicants have thoroughly reviewed the presently cited references and their various combinations as presented by the Examiner and believe the present amendments overcome the Examiner's rejections.

Rejections Under 35 U.S.C. § 103(a)

Benefits of the Applicants' Claimed Invention Over the Cited Prior Art

To provide the Examiner proper context for these amendments, applicants provide the following non-exclusive summary of certain deficiencies in the prior art and how the applicants' presently claimed invention provides a new and non-obvious benefit over that deficient art.

Traditional two-dimensional transducers used in the prior art for high speed three-dimensional imaging applications suffer from sensitivity loss due to the use of multiple signal transfer and distributions systems to connect them to ultrasound systems. Such prior art systems further require large numbers of pixels for two-dimensional steering capability with high resolution; high pixel number results in high electrical impedances—the voltage drop across an element divided by the current through the element. A cable (usually coaxial) traditionally drives the high impedance elements; the cable usually carries as many coaxes as pixels. This cable does not connect to the individual elements of the two-dimensional array thereby requiring another level of interconnections, usually PCB or multi-layer flexes, for transferring the signal to the transducer elements.

Such a system, as noted, requires an unwieldy cable for the multiple coax elements. The aforementioned cable impedance (*e.g.*, 50-75 ohms) cannot drive high electrical impedances of the individual transducer elements resulting in low sensitivity

levels. The prior art's reliance on multiple interconnect/transition devices to connect the cables to the transducer elements introducing additional capacitive loading and cross-talk. The presently claimed invention overcomes these sensitivity losses by eliminating, *inter alia*, the traditionally unwieldy cable used in transferring an ultrasound signal by making the transducer a part of the motherboard.

The applicants' invention offers a marked improvement over prior art systems, for example, one-dimensional acoustic arrays wherein the depth of focus is usually determined by passive acoustic focusing means and is fixed for each transducer; different applications requiring various depths of acoustic penetration utilize different transducers with specific depths of focus. In an embodiment of the present invention, and in the context of a two-dimensional array, the depth of focus is not fixed by the physical construction of the array, but is instead controlled by beam and/or area forming electronics and system software and by active electrical phasing of the two-dimensional array elements. This two-dimensional array connection with the motherboard, however, requires the design of the transducer to provide sufficient bandwidth for multiple frequency operation as a two-dimensional array must perform multiple tasks.

Two-dimensional arrays connected to the motherboard as described in the present invention are, as previously noted, controlled by beam forming electronics (*i.e.*, electronics for producing, receiving and analyzing an ultrasound beam wherein, generally, a one-dimensional set of echolocation data is generated using each ultrasound beam—one or more ultrasound pulses optionally separated in time). These beam forming electronics eliminate the necessity of using different transducers for different applications with different depths of focus. Instead, the present invention allows for one transducer connected to the motherboard to, as noted, perform multiple tasks.

By utilizing the presently claimed ultrasound system, in various embodiments, (1) the aforementioned cable is eliminated; (2) signal generation and detection can be electrically matched to the transducer elements increasing sensitivity; (3) the transducer can be attached to the motherboard benefiting from the pre-existing two-dimensional interconnection; and (4) any existing flex circuits can be terminated directly on the

motherboard row of pads. Applicants have incorporated a number of these aforementioned features into the claimed limitations of independent claims 1, 2, 15 and 48.

In claim 1, the ultrasound transducer assembly now recites "at least one transducer configured to provide sufficient bandwidth for multiple frequency operation" in addition to "electrically match[ing the transducer] to the signal generating and receiving unit." Claim 2 now exhibits a similar recitation in that the claimed ultrasound system comprises "at least one transducer configured to provide sufficient bandwidth for multiple frequency operation" where "the signal generating and receiving unit is electrically matched to the at least one transducer."

Claims 15 and 48 recite similar limitations. Claim 15 now includes a transducing element being "configured to provide sufficient bandwidth for multiple frequency operation, and electrically matched to the [signal generating and receiving] circuitry" whereas claim 48 comprises "ultrasound transducing means configured to provide sufficient bandwidth for multiple frequency operation, and electrically matched to the signal generating and receiving means."

Through these amendments, applicants respectfully contend the Examiner has failed to establish a *prima facie* case of obviousness as to the applicants' claimed invention. ***The cited references, either alone or in conjunction with any other cited reference, fail to teach all the claimed limitations of the applicants' invention.*** See In re Royka, 490 F.2d 981 (CCPA 1974) (requiring all claim limitation to be taught or suggested by the prior art). The absence of these claimed limitations in each reference is discussed in detail below.

Applicants further suggest, and as noted below, that certain references are non-analogous art and, in that regard, teach *away* from the applicants' claimed invention. See In re Oetiker, 977 F.2d 1443, 1446 (Fed. Cir. 1992) ("[i]n order to rely on a reference as a basis for rejection of an applicant's invention, the reference must either be in the field of applicant's endeavor or, if not, then be reasonably pertinent to the particular problem with which the inventor was concerned"); W.L. Gore & Associates, Inc. v. Garlock, Inc.,

721 F.2d 1540 (Fed. Cir. 1983), cert. denied, 469 U.S. 851 (1984) (requiring consideration of a reference in its entirety—including those aspects that teach away from the applicants' claimed invention); see also MPEP § 2141.01(a) (requiring a Section 103(a) reference to be analogous art).

Smith et al.

While the Examiner contends *Smith et al.* to teach "a signal generating and receiving unit (880, 890) and a cable-less coupling assembly," there is no mention in the reference as to multiple frequency bandwidth operation or electrical matching as in the applicants' claimed invention. Office Action at pg. 3. *Smith et al.*, in fact, notes in the background that "the design and fabrication problems of ***one-dimensional*** transducer arrays becomes ***almost overwhelming*** when extended to a ***two dimensional array***"; these "significant obstacles" make it "very difficult to achieve adequate ***sensitivity and bandwidth***" much less the ***multiple frequency bandwidth*** as required by applicants' presently claimed invention. *Smith et al.* at col. 2, l. 30-32, 35, 40-41 (emphasis added).

In that regard, Applicants suggest that *Smith et al.* does ***not*** pose a solution to the aforementioned obstacles and difficulties and especially not as claimed the by the Applicants. Further, Applicants suggest that a consideration of *Smith et al.* in its entirety would teach away from applicants' claimed invention—namely an ultrasound system providing for multiple frequency bandwidth operation and electrical matching. See W.L. Gore & Associates, Inc., 721 F.2d 1540.

Miller et al.

Miller et al. (5,267,221) has no discussion of multiple frequency bandwidth operation. Furthermore, *Miller et al.* presents no teaching of electrically matching the transducer to the signal generating and receiving unit. In fact, *Miller et al.* (filed in 1992) explicitly admits, in the background, that while "necessary to provide contact between an electrically conductive area on the underside of each transducer element of a two-dimensional array and a corresponding contact point on a circuit board," "[a] way of

achieving such contact while still providing the benefits of a backing 22[—impedance matching and acoustic dampening—]***does not currently exist***." *Miller et al.* at col. 2, l. 14-19, 21-23 (emphasis added); see also Miller et al. at col. 1, 30-32.

In that regard, Applicants suggest that *Miller et al.* does not pose a solution to the aforementioned problem and especially not as claimed the by the Applicants. Further, Applicants suggest that a consideration of *Miller et al.* in its entirety would teach away from applicants' claimed invention—namely an ultrasound system providing for electrical matching. See W.L. Gore & Associates, Inc., 721 F.2d 1540.

Kunkel, III

Kunkel's passing mention of "broad bandwidth operation" in the background is not equivalent to the applicants' claimed multiple *frequency* operation. *Kunkel* at col. 2, l. 41-42. Applicants' claimed invention requires sufficient bandwidth *in addition to* multiple frequency operation.

Notwithstanding, applicants assert *Kunkel* not be analogous art for the purposes of a 35 U.S.C. § 103(a) rejection. In re Oetiker, 977 F.2d at 1446. While *Kunkel* does concern an "acoustic backing for an ultrasonic transducer array," it is in the context of "affording points of electrical attachment to cable wires for the array which are removed from the piezoelectric material." *Kunkel* at Abstract; see also *Kunkel* at col. 5, l. 9-12 ("[w]ires from a ***cable*** may then be attached to the through-plated holes 54 of the printed circuit board to ***complete the electrical connections*** to the piezoelectric elements of the array") (emphasis added).

Applicants, therefore, suggest that a consideration of *Kunkel* in its entirety would teach away from applicants' claimed invention—namely an ultrasound system that does away with the inherent limitations of a coupling cable. See W.L. Gore & Associates, Inc., 721 F.2d 1540.

Chiang et al.

Chiang et al. presents no discussion of multiple frequency operation in a transducer or the bandwidth required to achieve such operation. In fact, *Chiang et al.* discusses a plurality of transducers each *singularly focused* at a different depth thereby suggesting the absence of multiple frequency operation much less the necessary bandwidth to achieve the same. See *Chiang et al.* at col. 2, l. 38-41. As such, applicants suggest that *Chiang et al.*—like *Kunkel*—is not analogous prior art in that "circuit board 1000A connects to a bus connector 1036, which is connected by a ***flexible ribbon cable*** or ***printed flex cable*** 1037 to a linear array of transducers 1038. A ***coax cable connector*** 1035 couples the scan head 1030 to external electronics." *Chiang et al.* at col. 31, l. 16-20; see In re Oetiker, 977. F.2d at 1446.

Applicants therefore suggest that consideration of *Chiang et al.* in its entirety would teach away from applicants' claimed invention—namely an ultrasound system that does away with the inherent limitations of a coupling cable. See W.L. Gore & Associates, Inc., 721 F.2d 1540 (Fed. Cir. 1983).

The applicants respectfully note that the Examiner's suggestion that the "[a]pplicants apparently include such flex circuit or flexible ribbon connection as 1037 of Chiang et al. to be cable-less," is incorrect. *Office Action* at 4. The Examiner, in support of this suggestion, refers to the filed specification wherein "the electrical connection to the two-dimensional array elements are made via many flex circuits." *Specification* at p. 6, l. 15.

A flexible circuit or 'flex circuit,' as referred to in the applicants' specification, is, for example, a printed circuit pattern using a layer of copper foil over a polymer base. Being made of a flexible material, the circuit can be multidimensional and can move, bend and twist without damage to the conductor. The applicants have enclosed a number of references supporting this definition in addition to visually evidencing a 'flex circuit' as ***not*** being a flexible ribbon connection as suggested by the Examiner. Ribbon cables, as referred to by the Examiner—and ***excluded*** from applicants' realm of

'cableless'—are those cables made of normal, round insulated wires arranged side-by-side and fastened together by a cohesion process to form a flexible ribbon.

Applicants have amended the relevant portion of the specification to more accurately delineate the scope of a flex-circuit versus a ribbon cable although the applicants' believe these definitions are well understood by one of ordinary skill in the art.

Gilmore

Gilmore fails to teach applicants' claimed multiple frequency operation in a transducer and electrical matching to the signal generating and receiving unit. While *Gilmore* discusses an "acoustic matching layer sheet 160 . . . to provide the desired acoustic impedance matching," this differs from the electrical matching in applicants' claimed invention. *Gilmore* at col. 5, l. 67-col. 6, l. 4.

With acoustic impedance, sound travels through materials under the influence of sound pressure. Because molecules or atoms of a solid are bound elastically to one another, the excess pressure results in a wave propagating through the solid. In that context, acoustic impedance of a material is defined as the product of density and acoustic velocity of that material.

Electrical impedance, on the other hand, is a distinguishing characteristic of piezoelectric elements. Electrical impedance differs substantially from the impedance of non-piezoelectric dielectric elements when driven at high-enough frequencies; the difference stems from the coupling of electrical energy input to mechanical motion output. In that context, electrical impedance is defined as the voltage drop across an element divided by the current through the element.

Electrical matching, as in the applicants' claimed invention, increases sensitivity between the signal generation/receiving elements and the transducer elements.

Miller

Miller (6,551,248) discusses the possibility of applying a matching layer 812 over a piezoelectric ceramic element 814 to "provide a larger operating bandwidth." *Miller* at col. 9, l. 43-49. *Miller* does not, however, teach the configuration of the transducer to provide, as in the case of Applicants' claim 1, "*sufficient* bandwidth for ***multiple frequency operation***" (emphasis added). There is a significant difference between merely providing more bandwidth (per *Miller*) and the bandwidth necessary for multiple frequency operation (as claimed in the present invention). For example, and as specifically noted by the applicants in paragraph **[0014]** of the filed specification of the present application, "for many ultrasound transducers **100% of the bandwidth is necessary for multiple frequency operations**" (emphasis added).

Despite the possibility of larger operating bandwidth in *Miller*, it may nonetheless be insufficient for allowing for multiple frequency operations much less single frequency operations. *Miller* provides no suggestion that the larger operating bandwidth is for the purpose of multiple frequency operations as there is no discussion in *Miller* as to multiple frequency operations. Applicants find no suggestion as to the inherency of larger bandwidth and multiple frequencies, especially absent any reference to multiple frequencies.

Applicants also note that to the extent the Examiner might continue to rely on *Miller* (6,551,248) for the basis of a 35 U.S.C. § 103(a)—or any other rejection—Applicants are capable of 'swearing behind' the reference pursuant to 37 C.F.R. § 1.131(a). Applicants believe, based on their present remarks, however, such an affidavit to be unnecessary and reserve submission of such an affidavit at the present time. Should the Examiner elect to issue another action, final or otherwise, relying on *Miller*, Applicants would respectfully request a courtesy call from the Examiner as to his intention so that the proper affidavit may be submitted prior to issuance of that action whereby prosecution of the present application may advance without unnecessary delay.

Due to applicants' ability to 'swear behind' *Miller*—thereby making the issue moot—applicants also refrain from commenting on the Examiner's interpretations with regard to *Imran et al.* (6,569,102). *Office Action* at 7.

Daigle

Daigle, too, fails to teach all the claimed elements of applicants' invention either alone or in combination with any of the other cited references. *Daigle* discusses only multiple software operations and ***processor*** bandwidth—not ***transducer*** bandwidth for multiple frequency operation. See *Daigle* at col. 2, l. 46-48. Further, *Daigle* lacks any teaching of electrical matching as is found in applicants' claimed invention.

Summary of Absent Teachings in Cited References

Applicants, for the convenience of the Examiner, summarize the absent teachings from each of the following references used in the Examiner's October 25 rejection. Applicants also note where specific references teach away from the claimed subject matter of the applicants' invention.

Smith et al.:	Fails to teach multiple frequency bandwidth operation or electrical matching; teaches away from electrical matching;
Miller et al.:	Fails to teach multiple frequency bandwidth operation or electrical matching; teaches away from electrical matching;
Kunkel, III:	Fails to teach multiple frequency bandwidth operation; teaches away from cableless coupling;
Chiang et al.:	Fails to teach multiple frequency bandwidth operation; teaches away from cableless coupling
Gilmore:	Fails to teach multiple frequency bandwidth operation or electrical matching
Miller:	Fails to teach multiple frequency bandwidth operation; subject to 37 C.F.R. § 1.131(a) affidavit
Daigle:	Fails to teach multiple frequency bandwidth operation or electrical matching

CONCLUSION

Applicants believe the Examiner's rejections of October 25, 2004 have been fully overcome. None of the Examiner's cited references—either individually or in combination with one another—teach an ultrasound system comprising a cableless coupling assembly *and* at least one transducer configured to provide sufficient bandwidth for multiple frequency operation *and* that is electrically matched to the signal generating and receiving unit.

Furthermore, the applicants believe that certain of those references cited by the Examiner—*Kunkel, III* and *Chiang et al.*—actually teach away from an ultrasound system utilizing cableless coupling. Applicants further believe that certain references—*Smith et al.* and *Miller et al.*—teach away from electrical matching. Applicants also contend the *Miller* reference (6,551,248) to *not* be prior art for the purposes of any 35 U.S.C. §§ 102 or 103 rejection subject to a Rule 131(a) affidavit.

Applicants respectfully remind the Examiner that should claim 1 be found in condition for allowance—and applicants contend it is—that claims 10-14 and 18-23 be reintroduced for examination as claim 1 represents a generic claim.

If the Examiner has any questions concerning this amendment or the prosecution of this application in general, the Examiner is invited to contact the applicants' undersigned representative at the number set forth below.

Respectfully submitted,
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